Training Range Environmental Evaluation and Characterization System (TREECS)

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14. ABSTRACT

Active military ranges contain munitions constituents (MC) and metal contamination that affect the usability and functionality of training facilities. Residues and disturbances from range operations can adversely impact the environment, including human and ecological health which require a variety of assessment tools to evaluate. Such impacts can also affect environmental compliance and range sustainment. Most Army live-fire training and testing ranges also have unique environments in which low-order and dud munitions may cause random and highly uncertain sources of MC contamination. Additionally, these ranges are under increased regulatory scrutiny, which in extreme cases has resulted in limitations being placed on training. The Training Range Environmental Evaluation and Characterization System (TREECS) has been developed by the Engineer Research and Development Center (ERDC) to assist Army analysts in managing ranges in such a manner that comply with environmental quality (EQ) objectives for toxic constituent stressors. The system hosts environmental characterization, risk management and evaluation tools and integrates the results for ease-of-use and reliability for MC. Specifically, the system automates conceptual model formulation and model parameter population across scales and pathways; formulates and couples first principle MC fate/transporttransformation-sequestration models with hydraulic models; and provides a single tool that bridges the gap between migration assessment and risk management and range sustainment. TREECS is currently being tested for use in the Army?s Operational Range Assessment Program (ORAP). This presentation will discuss the overall TREECS framework and capabilities along with a case study demonstrating those capabilities.

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TRAINING RANGE ENVIRONMENTAL EVALUATION AND CHARACTERIZATION SYSTEM (TREECS)

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Active military ranges contain munitions constituents (MC) and metal contamination that affect the usability and functionality of training facilities. Residues and disturbances from range operations can adversely impact the environment, including human and ecological health, which require a variety of assessment tools to evaluate. Such impacts can also affect environmental compliance and range sustainment. Most Army live-fire training and testing ranges also have unique environments in which low-order and dud munitions may cause random and highly uncertain sources of MC contamination. Additionally, these ranges are under increased regulatory scrutiny, which in extreme cases has resulted in limitations being placed on training. The Training Range Environmental Evaluation and Characterization System (TREECS) has been developed by the Engineer Research and Development Center (ERDC) to assist Army analysts in managing ranges in such a manner that comply with environmental quality (EQ) objectives for toxic constituent stressors. The system hosts environmental characterization, risk management and evaluation tools and integrates the results for ease-of-use and reliability for MC. Specifically, the system automates conceptual model formulation and model parameter population across scales and pathways; formulates and couples first principle MC fate/transport-transformation-sequestration models with hydraulic models; and provides a single tool that bridges the gap between migration assessment and risk management and range sustainment. TREECS is currently being tested for use in the Army's Operational Range Assessment Program (ORAP). This presentation will discuss the overall TREECS framework and capabilities along with a case study demonstrating those capabilities.

TREECS Problem Statement

- Residues and disturbances from range operations can impact the environment, including human and ecological health. Such impacts can impact environmental compliance and range sustainment.

- Army live fire training and test ranges have unique environments in which low-order and unexploded ordnance (dud munitions) are likely to cause random and highly uncertain sources of MC contamination.

- ***An assessment tool is needed to forecast if, when, and at what level MC concentrations in off-range media (groundwater, surface water, and sediment) may exceed protective health benchmarks.***

TREECS Solution / Approach

Training Range Environmental Evaluation and Characterization System (TREECS) is a client-based system that provides forecasts of Munitions Constituents (MC) fate on and off range based on munitions use on range.

Development Approach:

Formulate and couple screening level MC fate/transport-transformation-sequestration models in an integrated framework for fast assessments with a minimal amount of user input.

Partners:

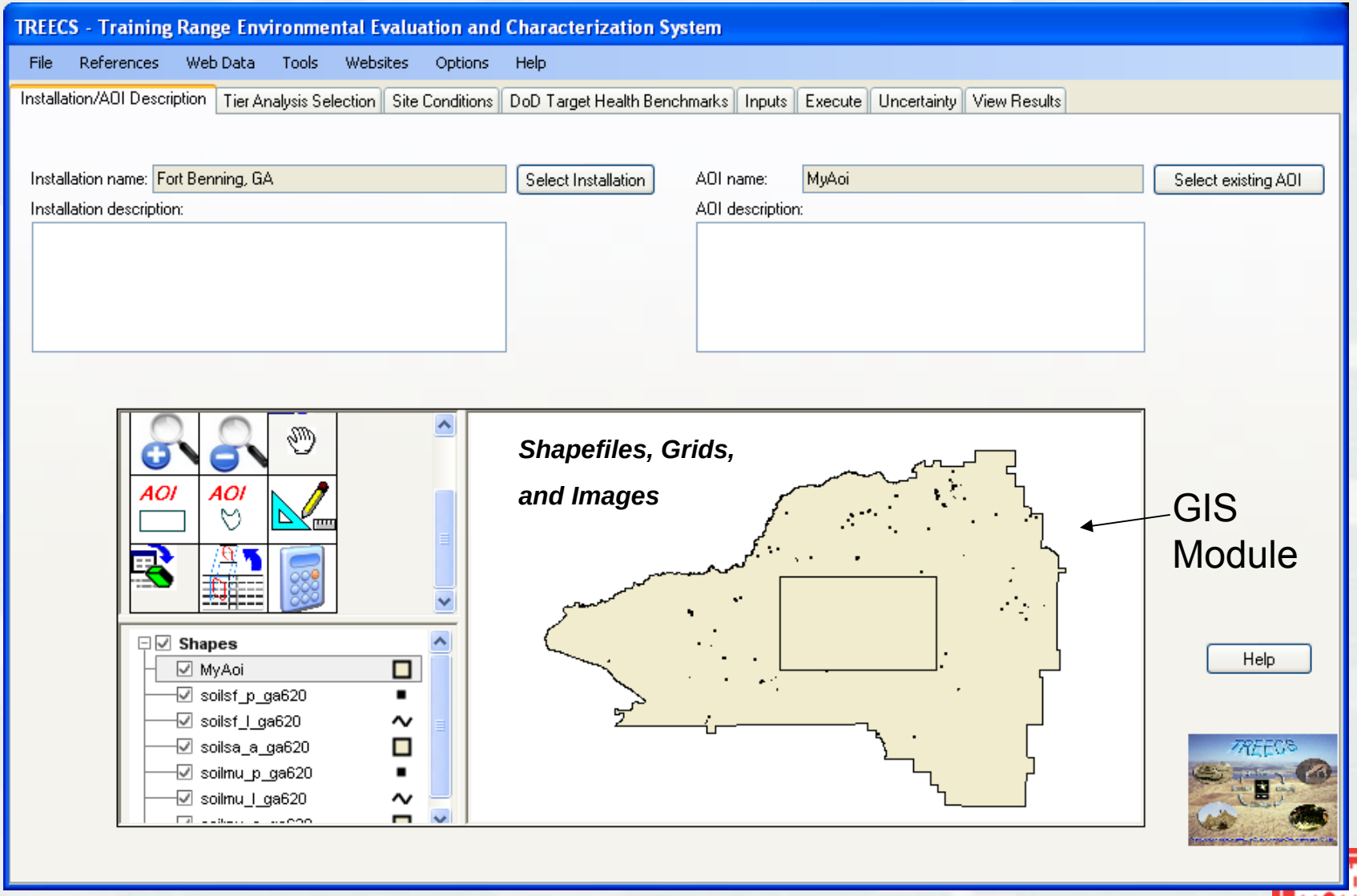
PNNL, AEC, CHPPM, ITL, and EL

http://el.erdc.usace.army.mil/treecs/

TREECS Components

- Framework for Tier 1 and 2 assessments
- Constituent databases
- Health Benchmark database
- Munitions database
- MC residual mass loading module based on munitions use
- GIS module
- Hydro-geo-characteristics toolkit (HGCT) for estimating input parameters
- Models for soil, surface water, vadose zone, and groundwater
- Simplified user input interfaces for models (GUIs)
- Viewers for results
- Sensitivity and uncertainty module for Tier 2 assessments

TREECS Main Screen



GIS Functions/Tools

 - For opening individual GIS files

 - For saving individual GIS files

 - For resampling a grid

 - For zooming into an area in the workspace

 - For zooming out of an area in the workspace

 - For panning in the workspace

- For creating a rectangular AOI shapefile in the workspace

- For creating a polygon AOI shapefile in the workspace

 - For measuring length and area in the workspace

 - For converting a shapefile to a grid

 - For extracting a subset of a grid

 - For creating slope grid from DEM and performing simple arithmetic operations on a grid

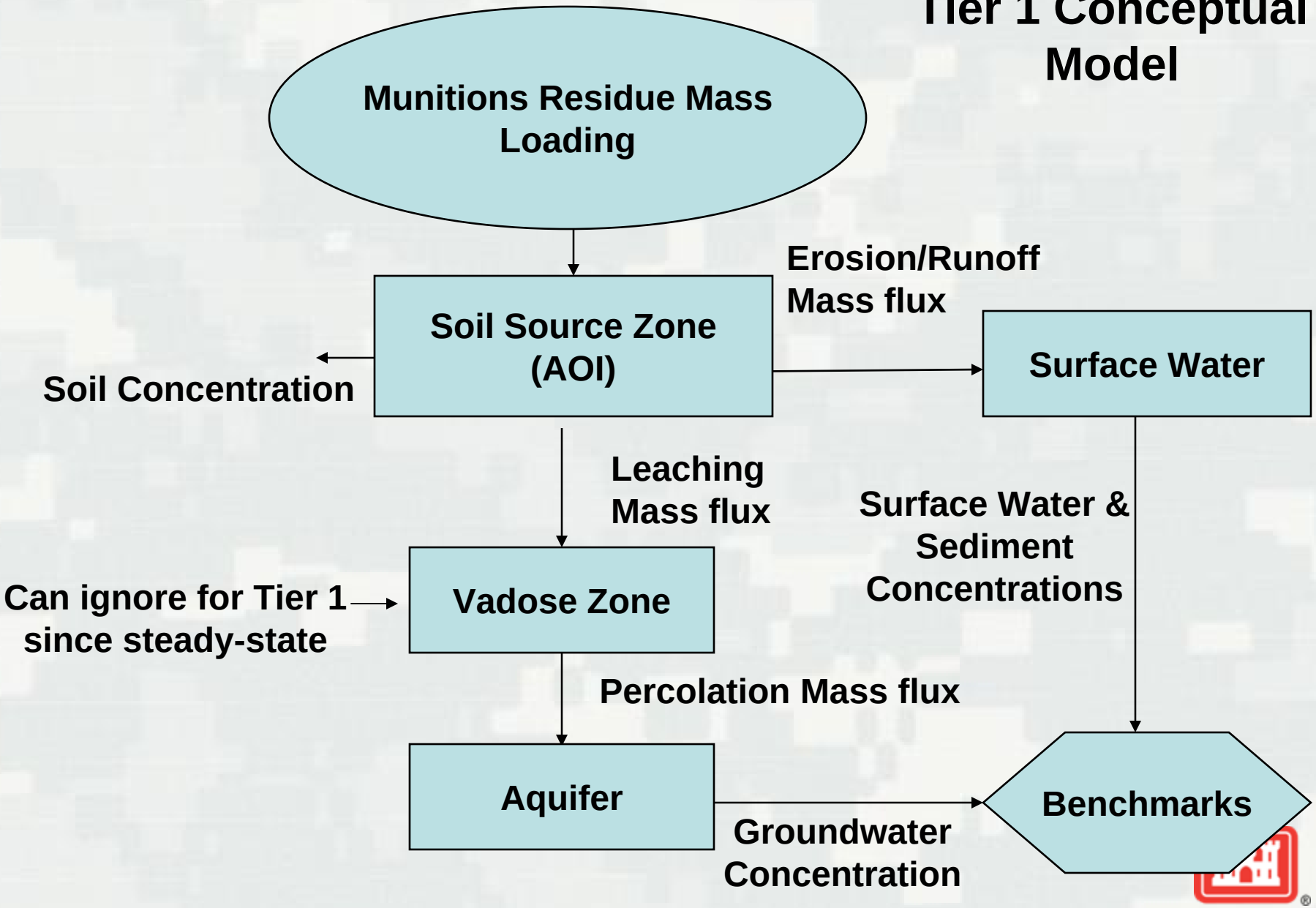
Hydro-Geo-Characteristics Toolkit (HGCT)

- To aid the user in determining input variables required by TREECS models
  - Soil Properties
  - Soil erosion rate
  - Hydrology (infiltration, runoff, ET, etc.)
  - Darcy velocity
- Allows *point* (single value) and *spatially- varying* composite estimates
- Spatial option requires use of GIS module in TREECS or externally developed map files (grids)

Tiered Approach

- Tier 1 (screening)
  - Steady-state, no degradation, worse case, highly conservative
  - Requires little data
  - Can be applied very quickly
  - Indicates whether a problem could ever potentially exist; if so, proceed to Tier 2
- Tier 2 (more comprehensive)
  - Time-varying, much more realistic and accurate
  - Requires more data
  - Requires more time to set up and apply, but still can be done relatively quickly
  - Can be used to determine when benchmark exceedence may occur
  - Useful for evaluating range management strategies

Tier 1 Conceptual Model



Tier 1 Model Primary Assumptions

- Area of Interest (AOI) is homogeneous
- Constant loading of MC into impact area (could possibly add firing points later)
- Soil concentrations are at steady-state
- No decay/degradation or volatilization, except for surface water volatilization
- No losses between the AOI and receiving surface water

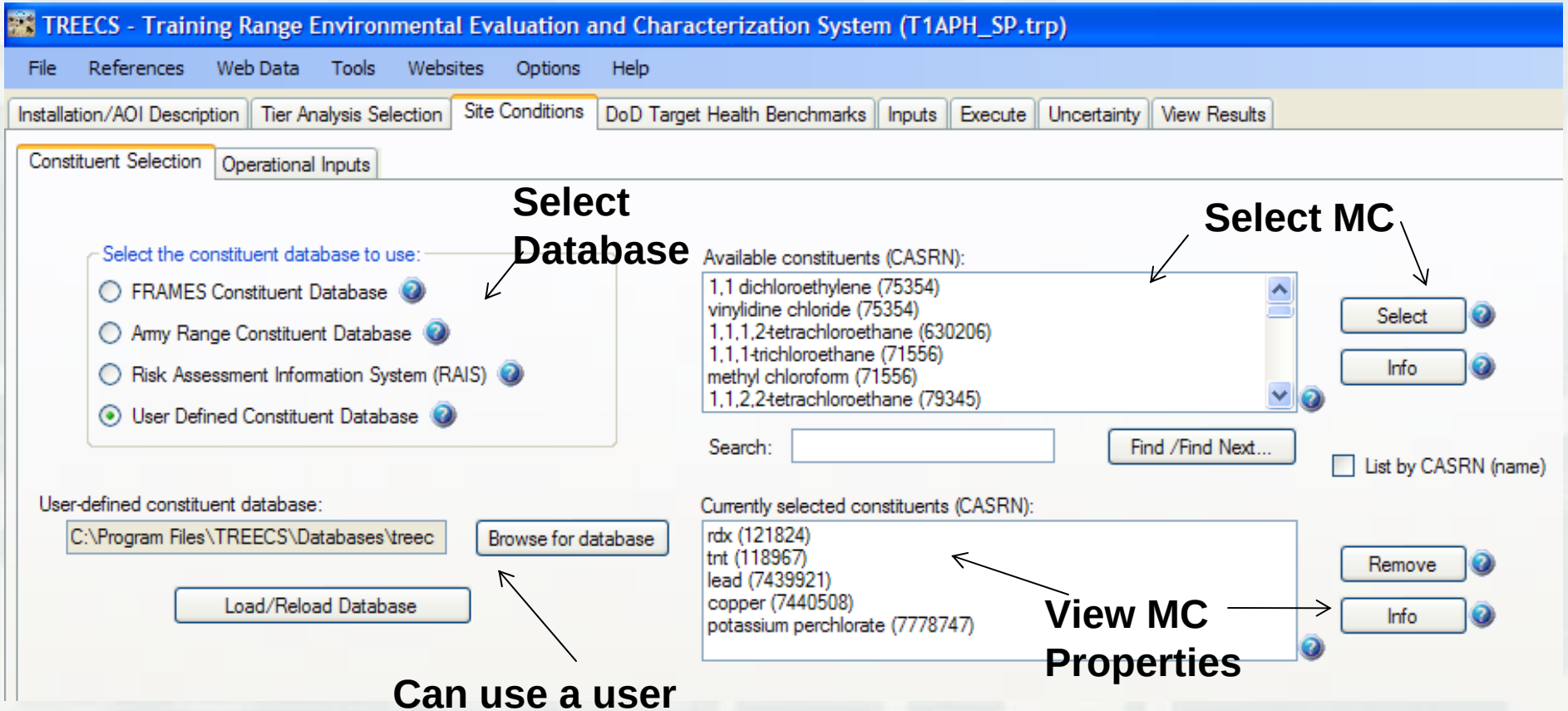
Tier 1 Modules

- MC mass loading based on munitions use
- Constituent databases
- Benchmark database
- Hydro-geo-characteristics toolkit (HGCT) for estimating input parameters (covered in separate session)
- GIS module for viewing of spatial info and for use in developing gridded info for HGCT spatial (covered in separate session)
- Steady-state soil model
- MEPAS Aquifer model with inputs simplified for Tier 1
- RECOVERY surface water model with inputs simplified for Tier 1
- Viewers for results

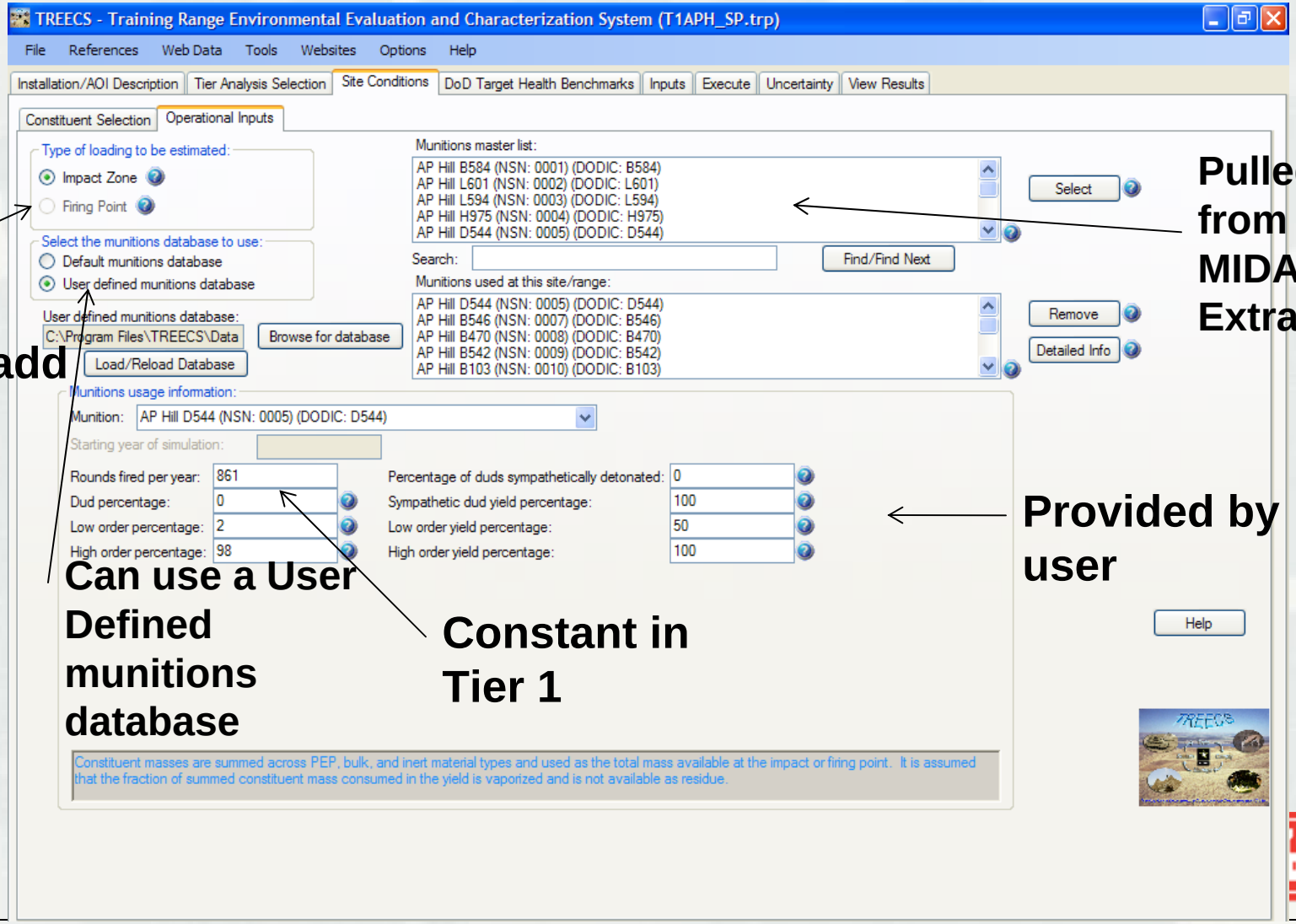
Constituent Database Module (Constituent Selection)

- Available Databases
  - FRAMES
  - Risk Assessment Information System (RAIS)
  - Army Range Constituent Database
  - User Defined (build from Con DB editor tool starting with a copy of the FRAMES (FUI) DB)
- For selecting MC and their properties
- Contains physical/chemical properties for MC and other contaminants
- Can change property values within the TREECS application, but it does not change database value

Constituent Selection



MC Residue Mass Loading Module (Operational Inputs)



Could add Firing Points

Pulled from MIDAS Extract DB

Provided by user

Can use a User Defined munitions database

Constant in Tier 1

MC Residue Mass Loading

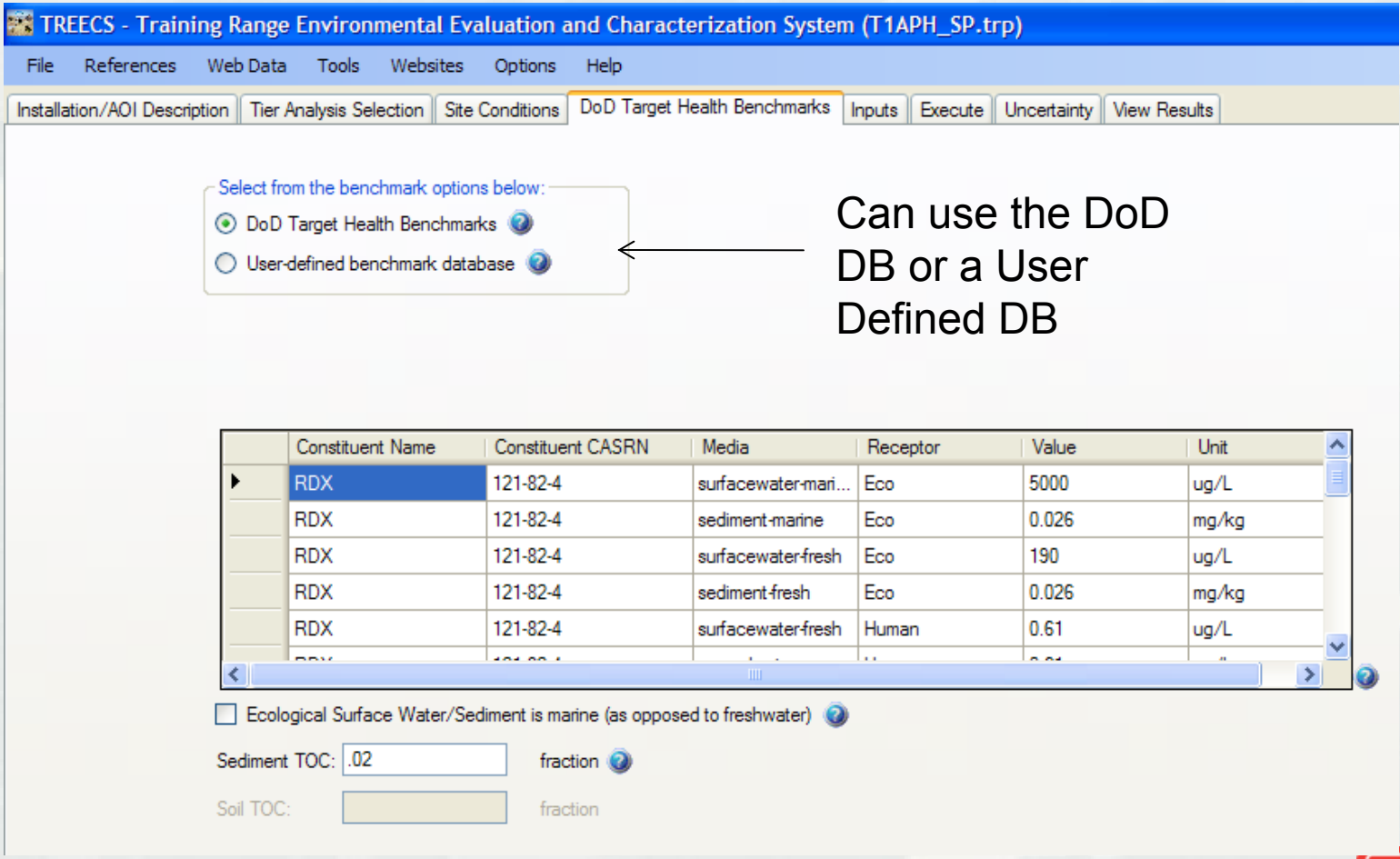
$$L_{i,k} = \sum_{j=1}^{j=n} \left\{ N_{j,k} M_{i,j} \left[\frac{LO_{j,k}\left(100 - Y_{LOj,k}\right) + HO_{j,k}\left(100 - Y_{HOj,k}\right) + DUD_{j,k} SYM_{j,k}\left(100 - Y_{SYMj,k}\right)}{100} \right] \right\}$$

$L_{i,k}$	=	Loading for constituent I for year k, g/yr
$DUD_{j,k}$	=	percent of duds for munitions item j for year k
$HO_{j,k}$	=	percent of high order detonations for munitions item j for year k
$LO_{j,k}$	=	percent of low order detonations for munitions item j for year k
$M_{i,j}$	=	mass of constituent i in munitions item j delivered to impact area, g/item
$N_{j,k}$	=	number of munitions item j fired for year k
n	=	total number of munitions items used at AOI
$SYM_{j,k}$	=	percent of sympathetic detonation of duds for munitions item j for year k
$Y_{HOj,k}$	=	percent yield of munitions item j due to high order detonation for year k
$Y_{LOj,k}$	=	percent yield of munitions item j due to low order detonation for year k
$Y_{SYMj,k}$	=	percent yield of munitions item j due to sympathetic detonation for year k

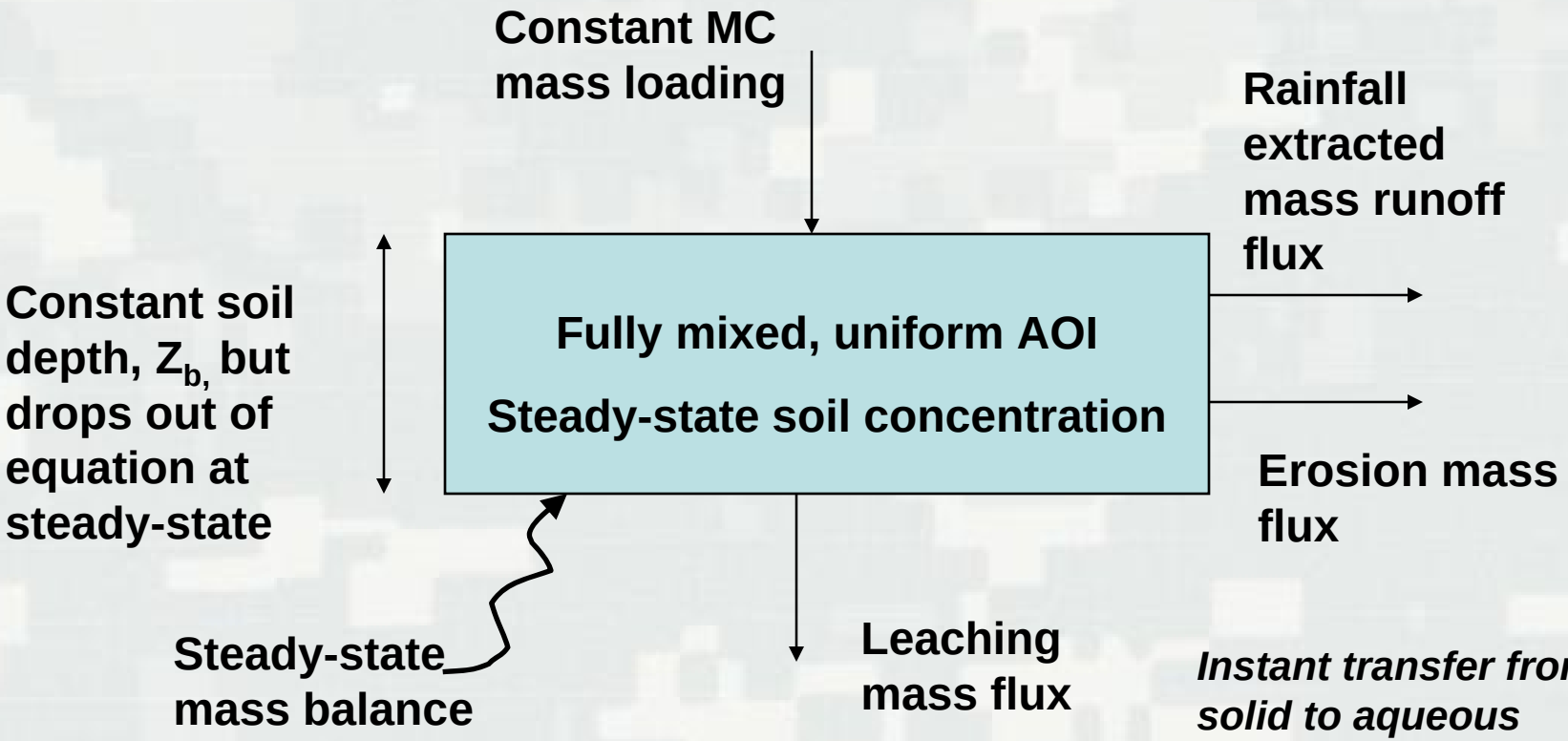
DoD Protective Health Benchmarks Database Construct

- Media and end point
  - Soil: human and eco (grayed out since no values currently)
  - Groundwater: human
  - Surface water: eco and human
  - Surface water sediments: eco

Benchmark Database Module

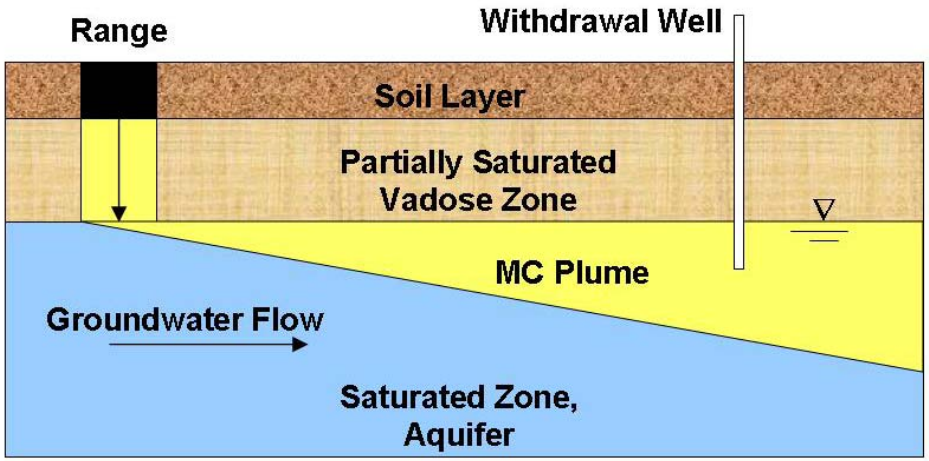


Tier 1 Soil Model



Instant transfer from solid to aqueous phase, no volatilization and no decay

Aquifer Model for Tier 1 – MEPAS Aquifer with less inputs (prescribed inputs)

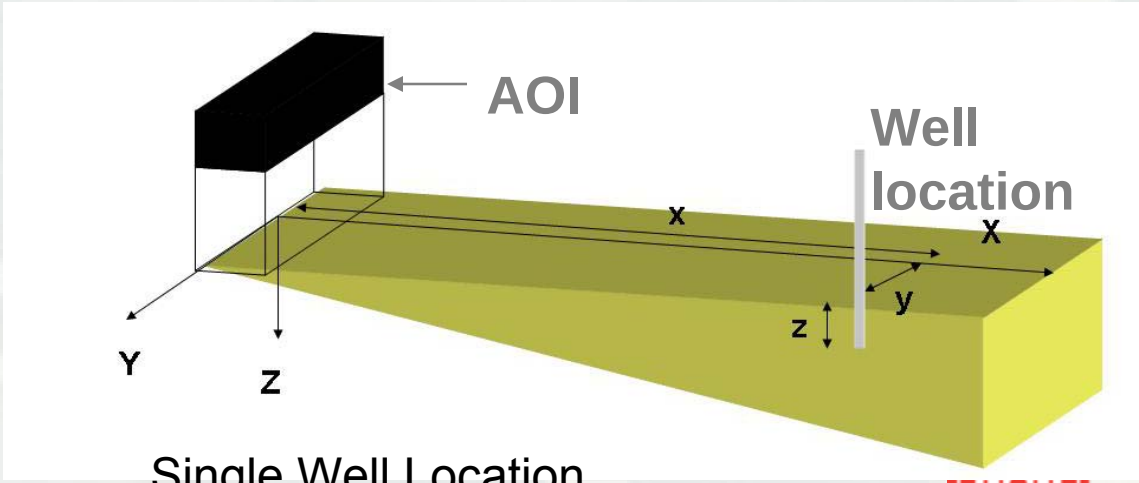


Conceptual Model

Don't need to model vadose zone for steady-state

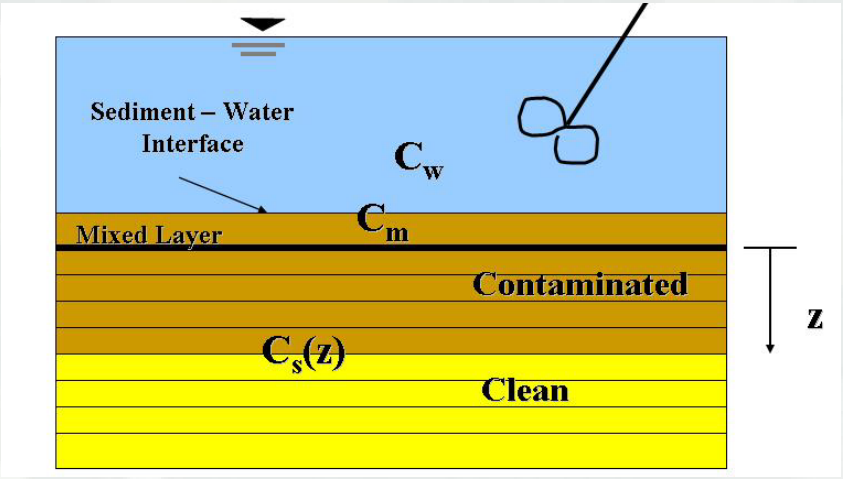
AOI length and width are input in Soil MUI

MEPAS coordinates



Single Well Location

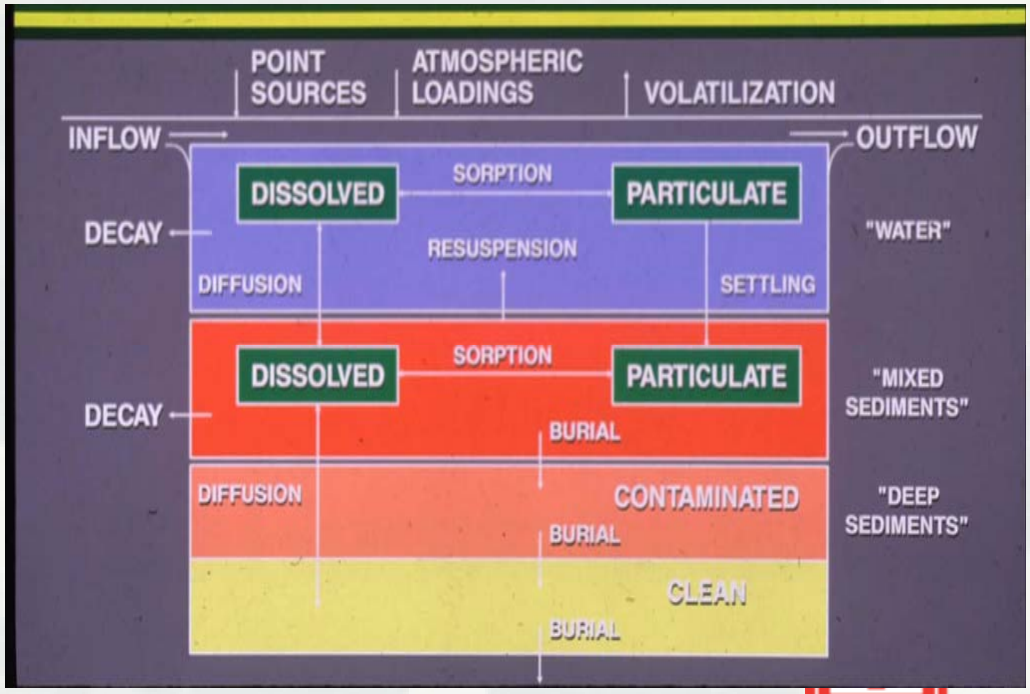
Tier 1 Surface Water Model (RECOVERY with fewer inputs – prescribed inputs)

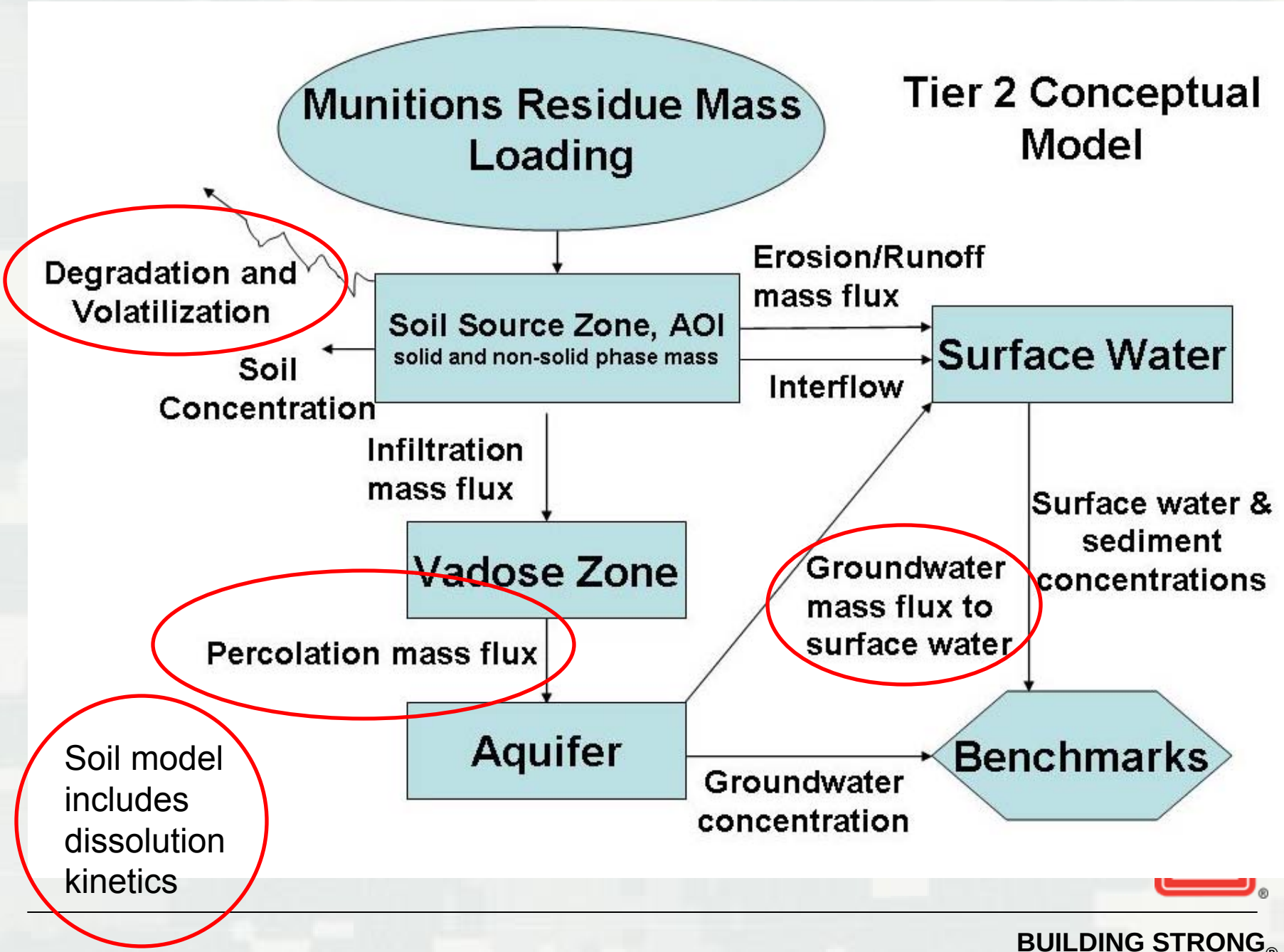


Model conceptualization

MC runoff/erosion dumps directly into surface water, i.e., no routing or in-path storage

Model fate processes




Tier 2 Conceptual Model
Munitions Residue Mass Loading
Degradation and Volatilization
Soil Source Zone, AOI
solid and non-solid phase mass
Soil Concentration
Erosion/Runoff mass flux
Interflow
Surface Water
Infiltration mass flux
Vadose Zone
Surface water & sediment concentrations
Groundwater mass flux to surface water
Percolation mass flux
Aquifer
Benchmarks
Groundwater concentration
Soil model includes dissolution kinetics

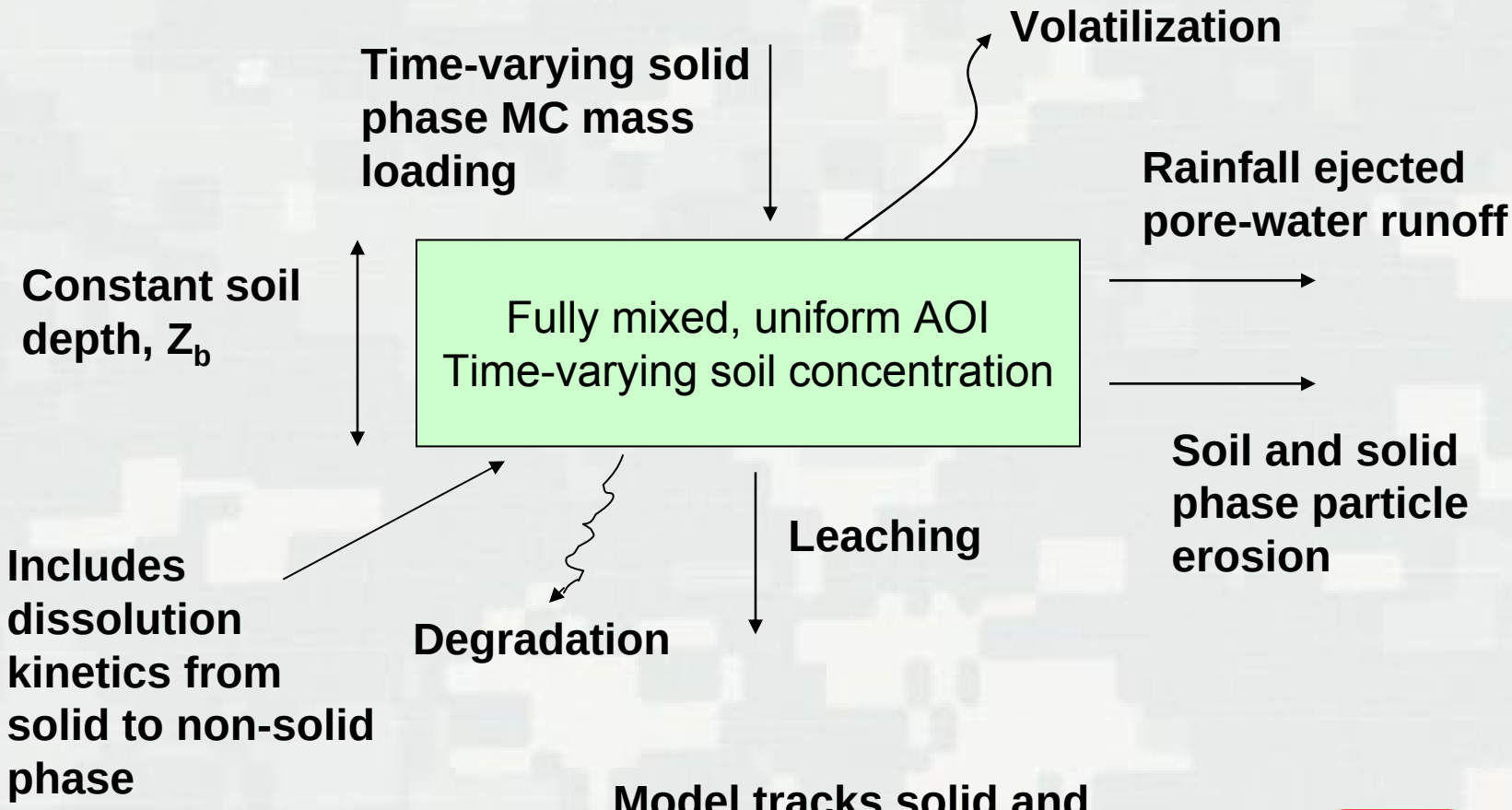
Tier 2 Model Primary Assumptions

- Area of Interest (AOI) is homogeneous
- Inputs and model responses are time-varying
- There can be fate losses, such as degradation (1st order)
- Sorption is linear, reversible equilibrium
- Solid and non-solid phase mass are tracked with dissolution
- No losses between the AOI and receiving surface water for runoff/erosion and interflow
- Steady-state hydrologic inputs (average annual conditions) like Tier 1
- Vadose transport is 1D vertical

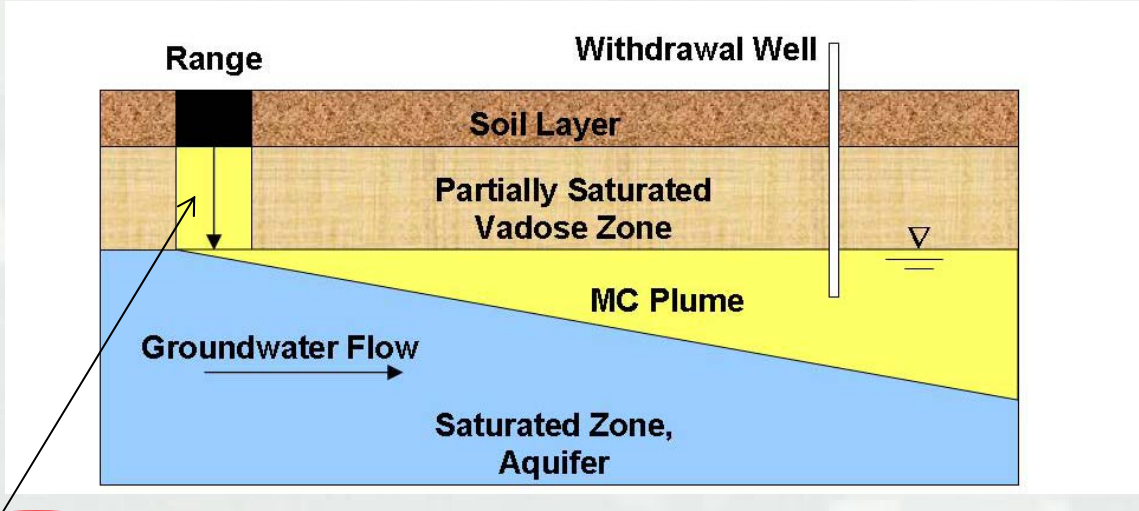
Tier 2 Modules

- Same as Tier 1 except for the following additions:
  - Tier 2 soil model is used instead of Tier 1 soil model
  - MEPAS Vadose Zone model and flux viewer
  - Contaminant Model for Streams (CMS); user must choose whether to use CMS or RECOVERY for surface water and sediments (default is RECOVERY)
  - Sensitivity and Uncertainty (S/U) based on Monte Carlo simulation with Latin Hypercube sampling
  - S/U viewers
  - Plus-SG Operator: allows aquifer discharge to surface water; transparent to user other than having to specify the aquifer discharge rate to surface water

Tier 2 Soil Model



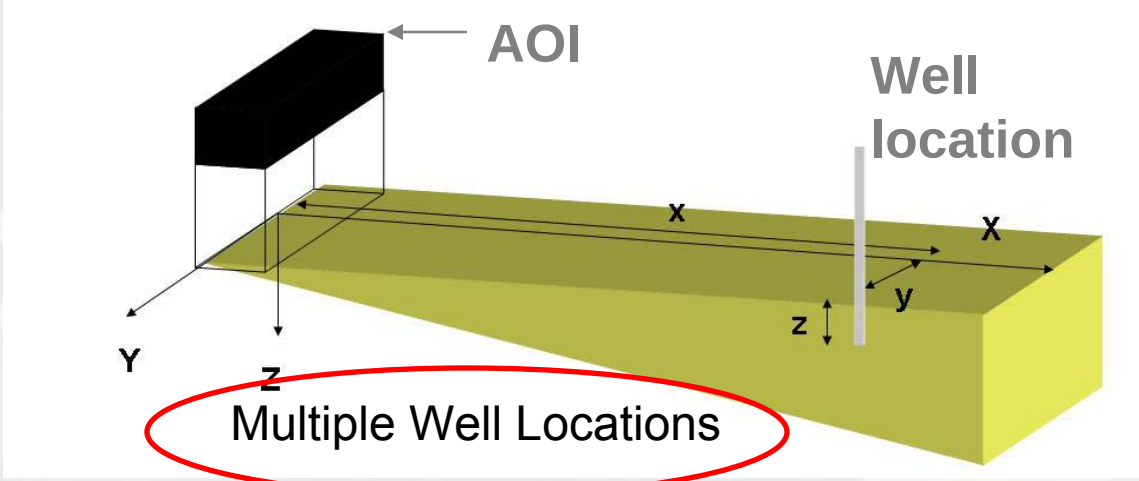
MEPAS Vadose & Aquifer Models for Tier 2 with full Capabilities



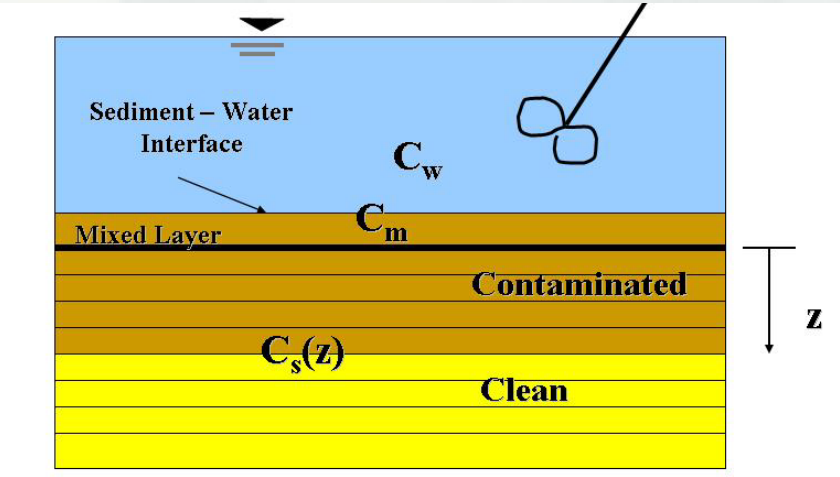
AOI length and width are input in Soil MUI

MEPAS coordinates

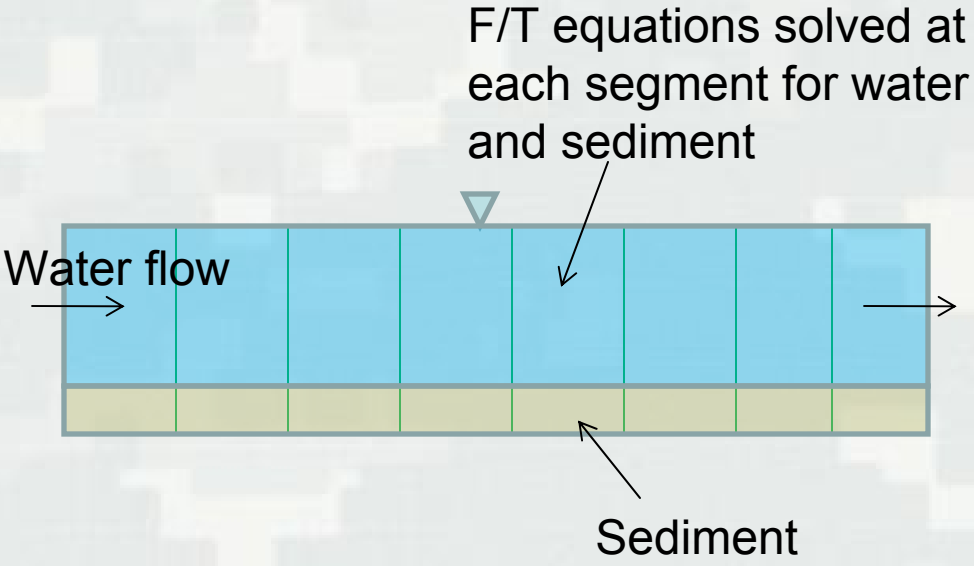
Vadose Zone included



Tier 2 Surface Water Models, RECOVERY and CMS with full Capabilities



RECOVERY Model conceptualization



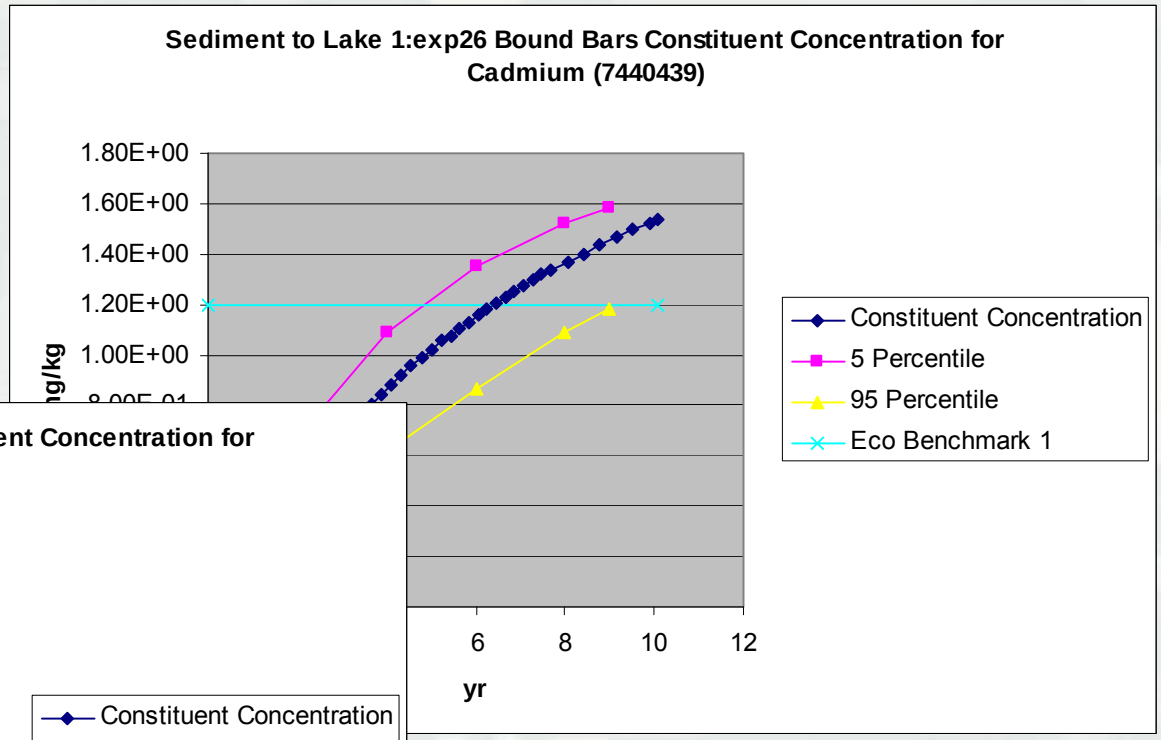
CMS conceptualization

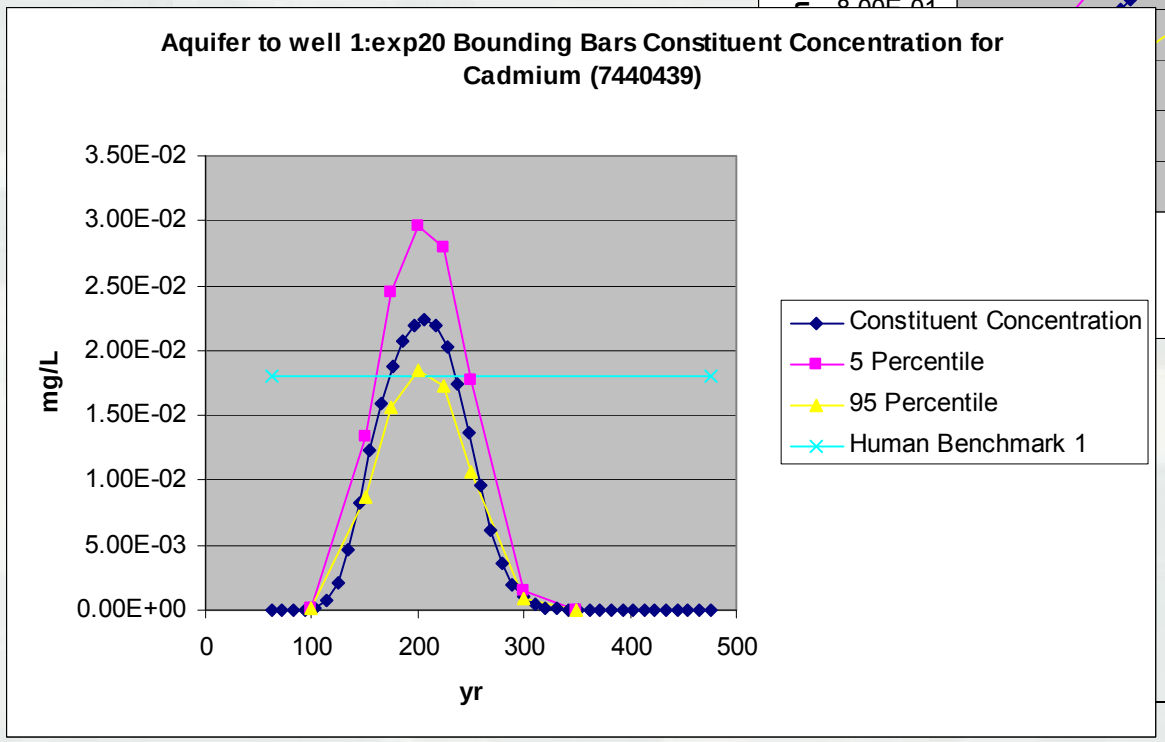
Sensitivity/Uncertainty Module

- Declare uncertain parameters
- Declare variables and their features to watch for output, e.g., aquifer concentration at specific years or peak concentration for simulation
- Specify the type of distribution and its statistics for each uncertain parameter, e.g., normal distribution with mean, upper and lower bounds, and standard deviation
- Set random seed and number of Monte Carlo iterations

S/U Example Output Viewer

Concentration versus time with confidence limits





TREECS Status

- Currently being tested and validated using existing training range data by EL, AEC, and CHPPM personnel
- Used to help support ORAP Phase II Assessments
- FY11-FY13 – Further enhancements to Tier 1 and Tier 2 modeling capabilities and database expansions
- FY11-FY13 – Development and Implementation of a Fully Explicit Physically Based Watershed Modeling capability within the TREECS Framework – *Useful for evaluating mitigation scenarios for multiple AOIs covering complex terrain*

Questions?

http://el.erdc.usace.army.mil/treecs/

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